MEMORANDUM FOR RECORD

SUBJECT: John Day Flow Modeling

CENWP-EC-HY was asked to quantify the hydraulic variations along the Columbia River from the McNary Dam tailrace to the John Day Dam forebay (Lake Umatilla). The hydraulic variations were quantified by determining the average velocities and average travel times over the total range of river flows through the length of the lake. The range of flows varied from 100,000 cfs to 325,000 cfs. The John Day Dam forebay elevation was set to 262.5 feet for all profile runs. The average velocities and travel times were also determined at five pre-selected cross sections, RM 291.92, RM 290.31, RM 252.81, RM 219.66, and RM 217.01 as requested by NOAA.

An HEC-RAS model of this stretch of the Columbia River was developed during a previous investigation of the drawdown options at the John Day Dam. The original model was developed using HEC-RAS River Analysis System, version 3.1.2, April 2004. This model was modified to determine the hydraulic variations along the Columbia. HEC-RAS is a 1-D model and provides a general feel for the impact of changing river flows. It does not get into the detail of small nuances that exist in an actual river.

On April 11, 2003, Acoustic Doppler Current Profiler (ADCP) and point velocity data were collected in the John Day Dam forebay at River Mile 217.2 by ENSR International for the Corps of Engineers. The results from this study are documented in **Acoustic Doppler Current Profiler and Point Velocity Measurement Field Data Collection, Lower Columbia River Projects**, dated July 9, 2003. The data from this study was compared to the data from the HEC-RAS model at cross section RM 217.01 (the closest cross section in the model to RM 217.2). The elevation of the river bottom was found by subtracting the total depth at the station from the water surface elevation on the day the data was collected. The ADCP cross section had the same general shape as the HEC-RAS cross section but lacked the details of the HEC-RAS cross section because there were only twelve ADCP stations compared to 36 stations in the HEC-RAS cross section. The ADCP and HEC-RAS cross sections are shown in Figure 1.

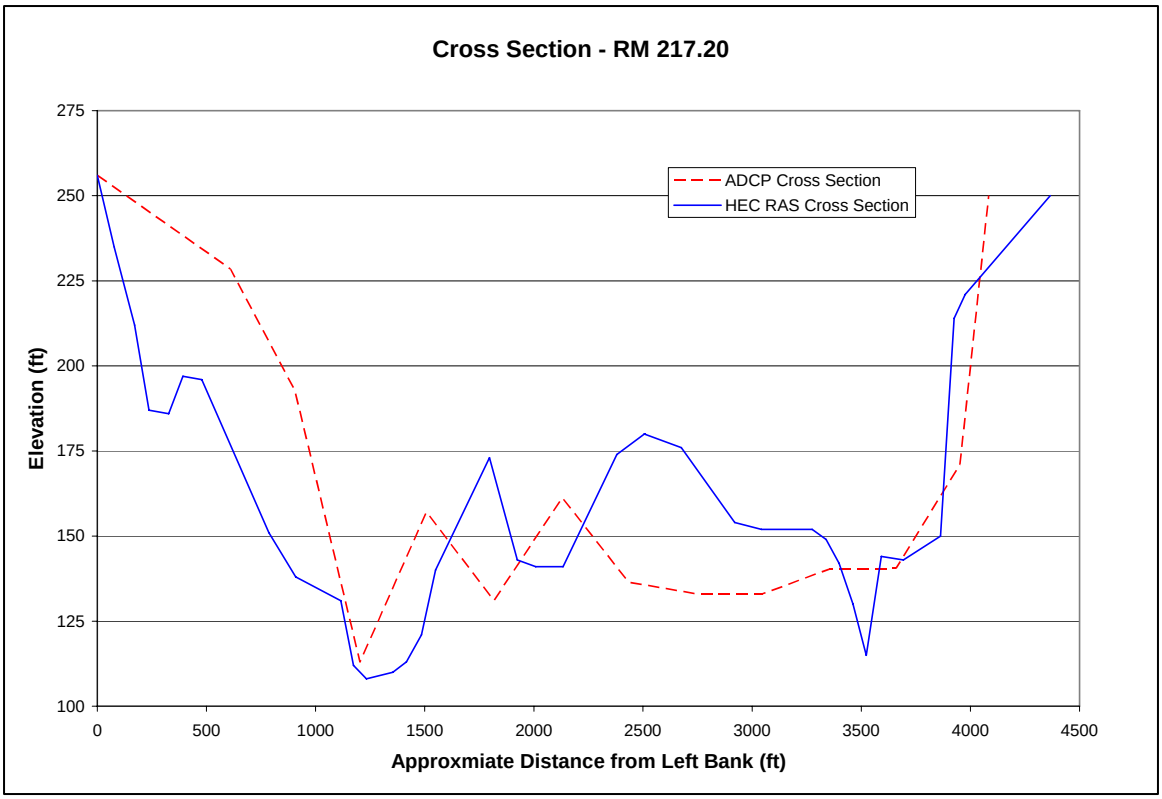


Figure 1: ADCP & HEC RAS Cross Sections at River Mile 217.20.

During the ADCP study, the velocities were taken at various depths at each station. Since HEC-RAS is a 1-D model it does not provide velocities at different depths. To be able to compare the velocities across the cross section, all of the velocities collected at each station during the ADCP study were averaged to provide one velocity for the station. The HEC-RAS model provided the velocities in five sections across the channel. The velocities collected during the ADCP study and those computed by HEC-RAS are shown below on Figure 2.

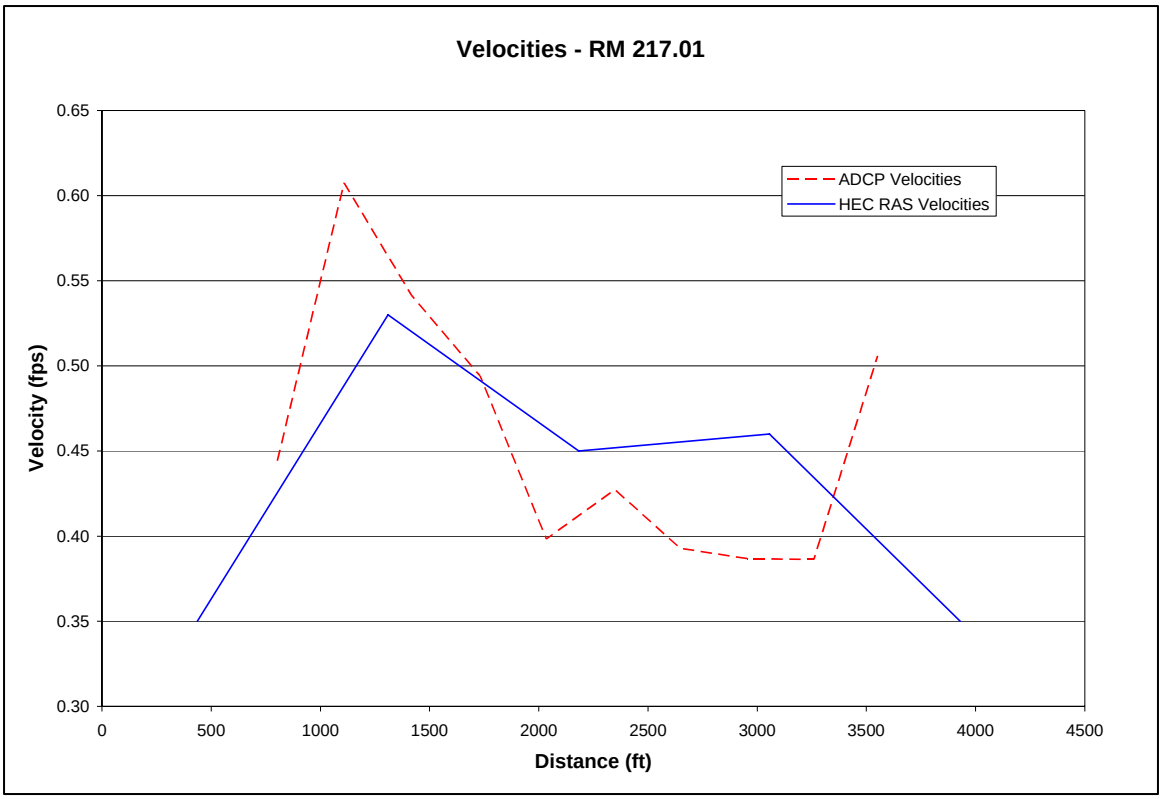


Figure 2: ADCP & HEC RAS Velocities at River Mile 217.20.

The velocities computed by HEC-RAS were 0.08 fps lower on the left side of the channel, almost the same in the middle of the channel, and 0.07 fps higher on the right side of the channel. The average velocity from the ADCP study for cross section RM 217.2 is 0.46 fps. The average velocity computed by the HEC-RAS model for cross section RM 217.01 is 0.44 fps.

Twelve different flow profiles were used in the HEC-RAS model. These profiles are shown in Table 1. The velocities at each cross section and travel times were computed for each flow. Since HEC-RAS provides an average cross section velocity at each cross section, the velocities were averaged from all cross sections to obtain the average velocity for each flow profile. The travel time is an estimate of time required for water particles to travel from McNary Dam to John Day Dam through the entire Lake Umatilla.

Table 1: Hydraulic Characteristics

Total River Flow (cfs)	Travel Times (hrs)	Average Velocity (fps)
100,000	278	0.57
115,000	242	0.65
133,000	209	0.75
140,000	199	0.79
150,000	186	0.84
163,000	171	0.91
170,000	164	0.95
189,500	147	1.05
200,000	140	1.11
225,000	124	1.24
275,000	102	1.49
325,000	87	1.73

The velocities listed above are an average over the length of Lake Umatilla (76 miles). The velocity at any given cross section can vary considerably from the average. Therefore, the velocities for the different river flows at five different cross sections were investigated. The average and maximum velocities for cross sections RM 291.92, RM 290.31, RM 252.81, RM 219.66, and RM 217.01 are shown in Tables 2 and 3, respectively. The velocity plots are shown in Figure 3.

Table 2: Average Velocity at Selected Cross Sections

Total Flow (cfs)	**Average Velocity at RM 291.92** (ft/s)	**Average Velocity at RM 290.31** (ft/s)	**Average Velocity at RM 252.81** (ft/s)	**Average Velocity at RM 219.66** (ft/s)	**Average Velocity at RM 217.01** (ft/s)
100000	1.39	1.89	0.41	0.26	0.23
115000	1.58	2.16	0.47	0.30	0.27
133000	1.81	2.47	0.54	0.35	0.31
140000	1.89	2.58	0.57	0.37	0.33
150000	2.01	2.75	0.61	0.39	0.35
163000	2.17	2.96	0.66	0.43	0.38
170000	2.25	3.07	0.69	0.44	0.40
189500	2.46	3.37	0.77	0.50	0.44
200000	2.58	3.53	0.81	0.52	0.47
225000	2.83	3.89	0.91	0.59	0.53
275000	3.31	4.53	1.11	0.72	0.64
325000	3.74	5.09	1.31	0.85	0.76

Table 3: Maximum Velocity at Selected Cross Sections

Total Flow (cfs)	**Maximum Velocity at RM 291.92** (ft/s)	**Maximum Velocity at RM 290.31** (ft/s)	**Maximum Velocity at RM 252.81** (ft/s)	**Maximum Velocity at RM 219.66** (ft/s)	**Maximum Velocity at RM 217.01** (ft/s)
100000	1.40	2.04	0.49	0.32	0.28
115000	1.60	2.33	0.56	0.36	0.32
133000	1.83	2.67	0.65	0.42	0.37
140000	1.91	2.80	0.68	0.44	0.39
150000	2.03	2.98	0.73	0.47	0.42
163000	2.19	3.20	0.79	0.51	0.46
170000	2.27	3.32	0.83	0.54	0.48
189500	2.49	3.65	0.92	0.60	0.53
200000	2.60	3.82	0.97	0.63	0.56
225000	2.87	4.23	1.09	0.71	0.63
275000	3.35	4.95	1.33	0.87	0.77
325000	3.79	5.59	1.57	1.03	0.91

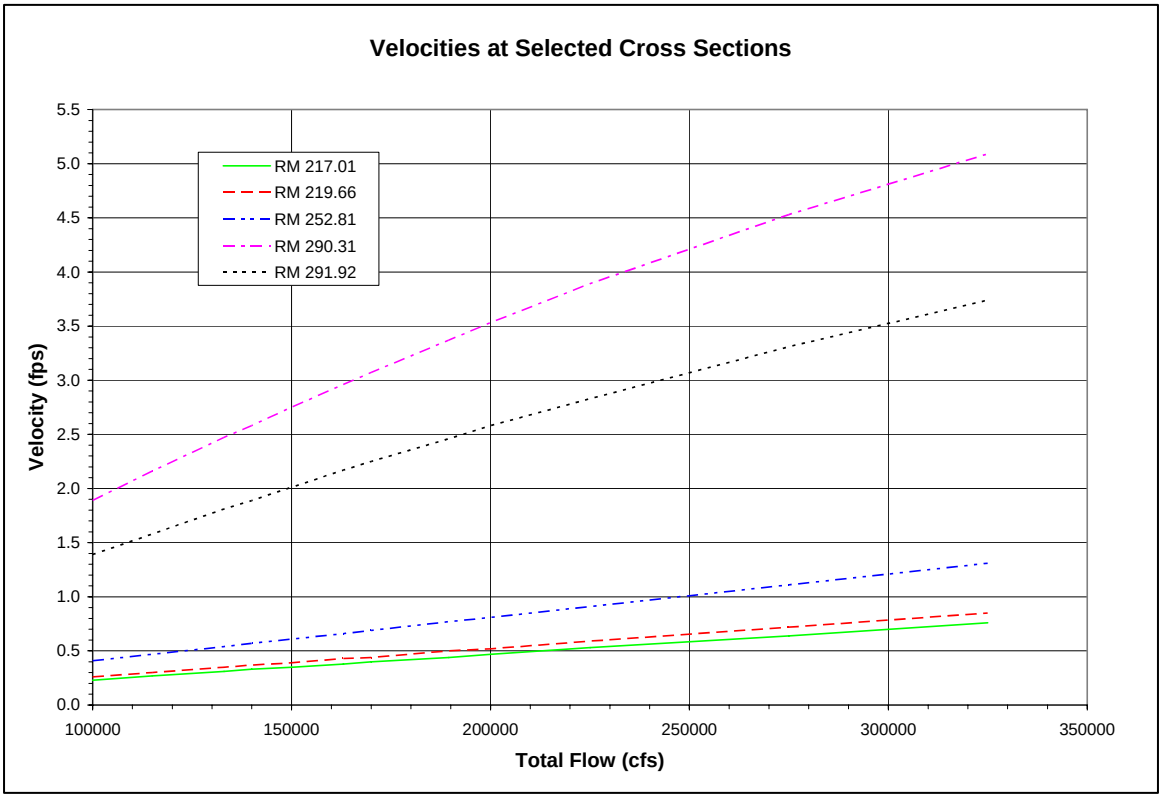


Figure 3: Velocity Plot for RM 291.92, RM 290.31, RM 252.81, RM 219.66, & RM 217.01.

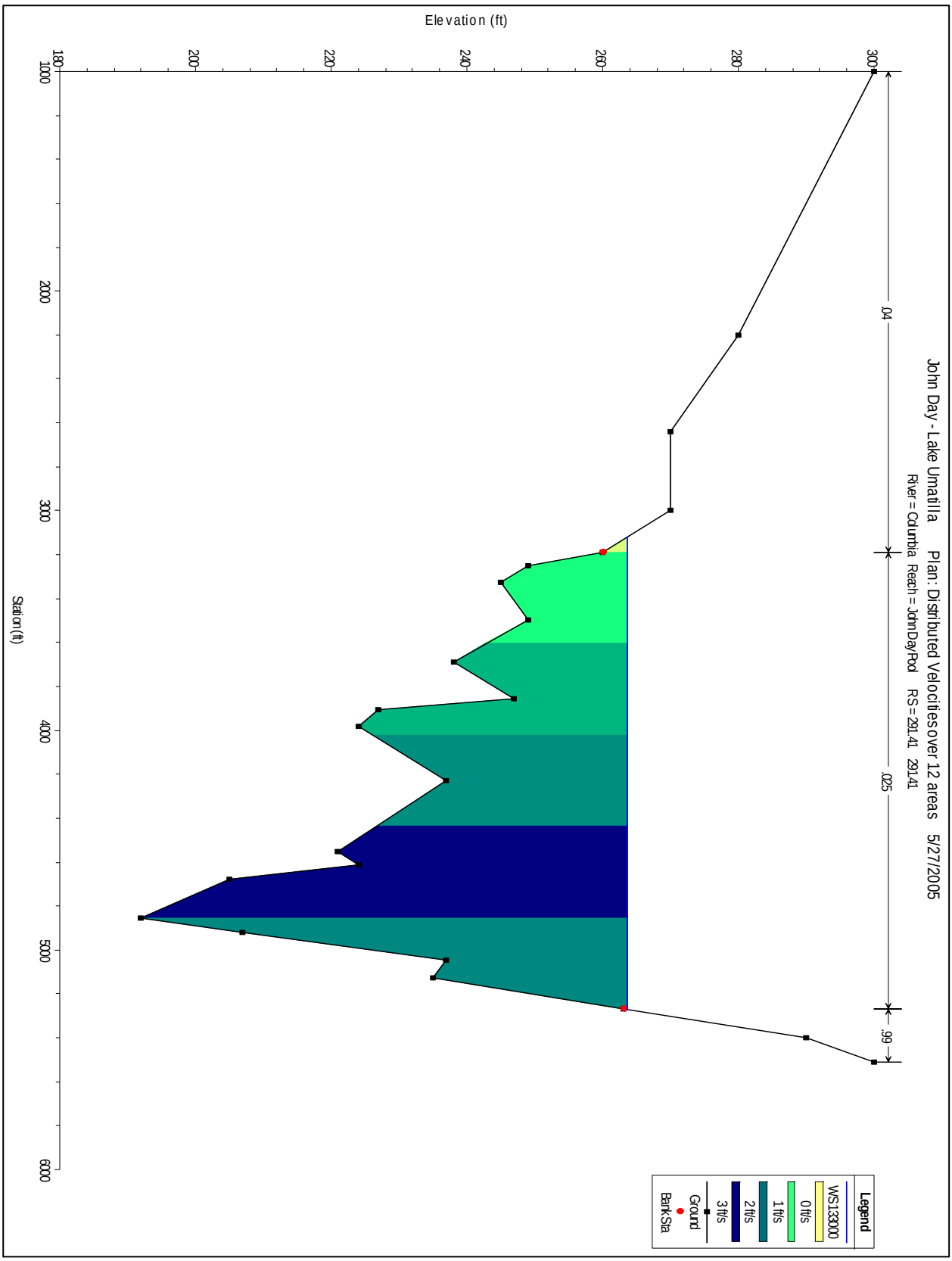
As can be seen from the table and plot, the velocity is much higher near the upper end of Lake Umatilla compared to the middle or lower end of reach.

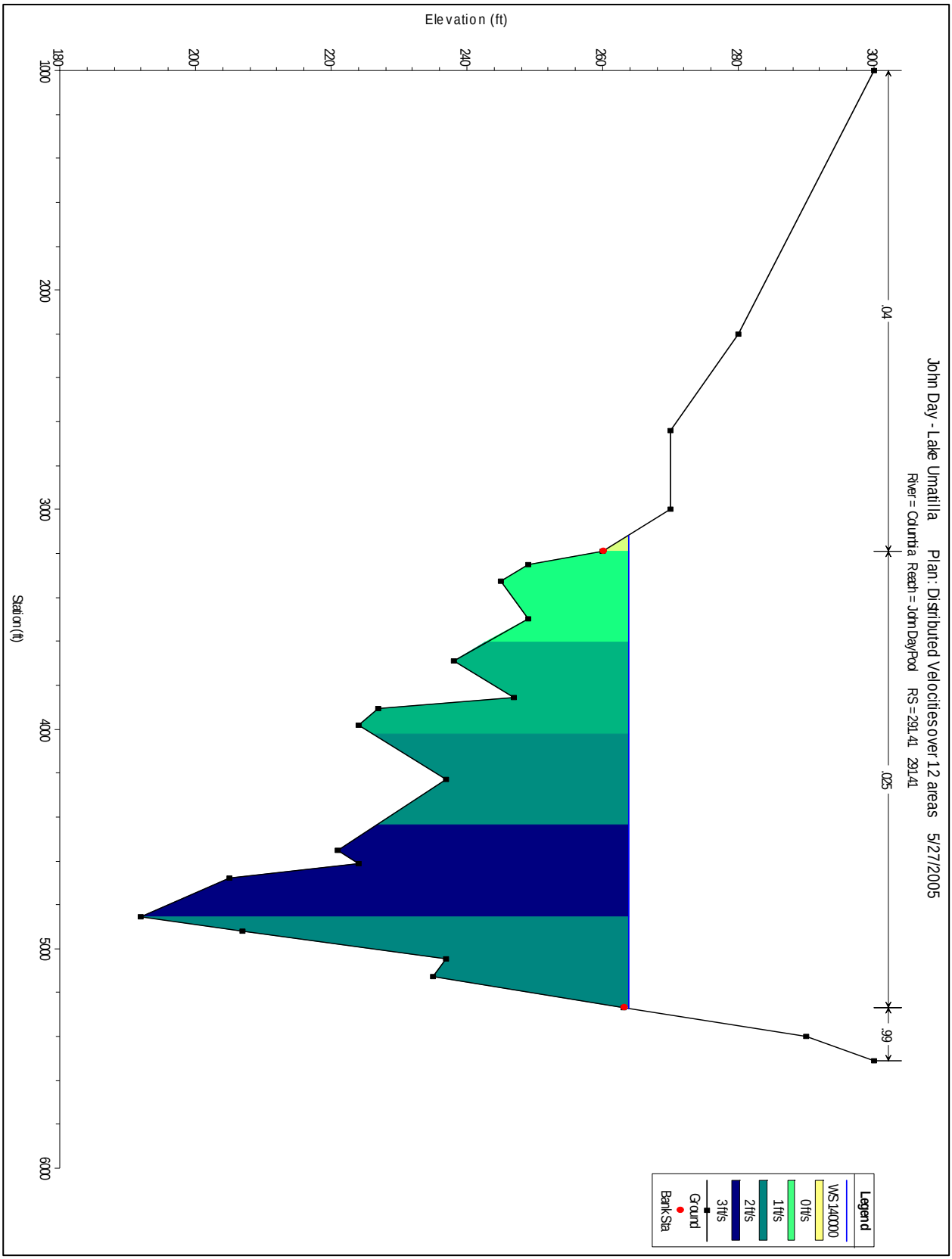
The difference between the average velocity and the maximum velocity can be used to estimate the variability of the velocity in the cross section. The smaller the difference, the less variability in the cross section. The difference between the average and maximum velocities for cross sections RM 291.92, RM 290.31, RM 252.81, RM 219.66, and RM 217.01 are shown in Table 4.

Table 4: Difference Between Average and Maximum Velocities at Selected Cross Sections

Total Flow (cfs)	**Difference Between Average & Maximum Velocities at RM 291.92** (ft/s)	**Difference Between Average & Maximum Velocities at RM 290.31** (ft/s)	**Difference Between Average & Maximum Velocities at RM 252.81** (ft/s)	**Difference Between Average & Maximum Velocities at RM 219.66** (ft/s)	**Difference Between Average & Maximum Velocities at RM 217.01** (ft/s)
100000	0.01	0.15	0.08	0.06	0.05
115000	0.02	0.17	0.09	0.06	0.05
133000	0.02	0.20	0.11	0.07	0.06
140000	0.02	0.22	0.11	0.07	0.06
150000	0.02	0.23	0.12	0.08	0.07
163000	0.02	0.24	0.13	0.08	0.08
170000	0.02	0.25	0.14	0.10	0.08
189500	0.03	0.28	0.15	0.10	0.09
200000	0.02	0.29	0.16	0.11	0.09
225000	0.04	0.34	0.18	0.12	0.10
275000	0.04	0.42	0.22	0.15	0.13
325000	0.05	0.50	0.26	0.18	0.15

HEC-RAS can estimate the flow distribution at each cross section. The flow distribution plots for four of the five selected cross sections with a total river flow of 133,000 cfs and 140,000 cfs are attached. The flow distribution plot for the cross section at RM 291.92 was not included because it was a cross section of the McNary Dam forebay and did not provide any useful information. The flow distribution for the cross section at RM 291.41 (the next cross section downstream) was included instead. Based on these plots, there is no noticeable difference between the flow distribution at 133,000 cfs and 140,000 cfs.


John Day - Lake Umatilla Plan: Distributed Velocities over 12 areas 5/27/2005
River = Columbia Reach = JohnDayPool RS = 291.41 291.41
Elevation (ft)
Station (ft)
180
200
220
240
260
280
300
1000
2000
3000
4000
5000
6000
.04
.025
.99
Legend
WS133300
0 ft/s
1 ft/s
2 ft/s
3 ft/s
Ground
Bank Sta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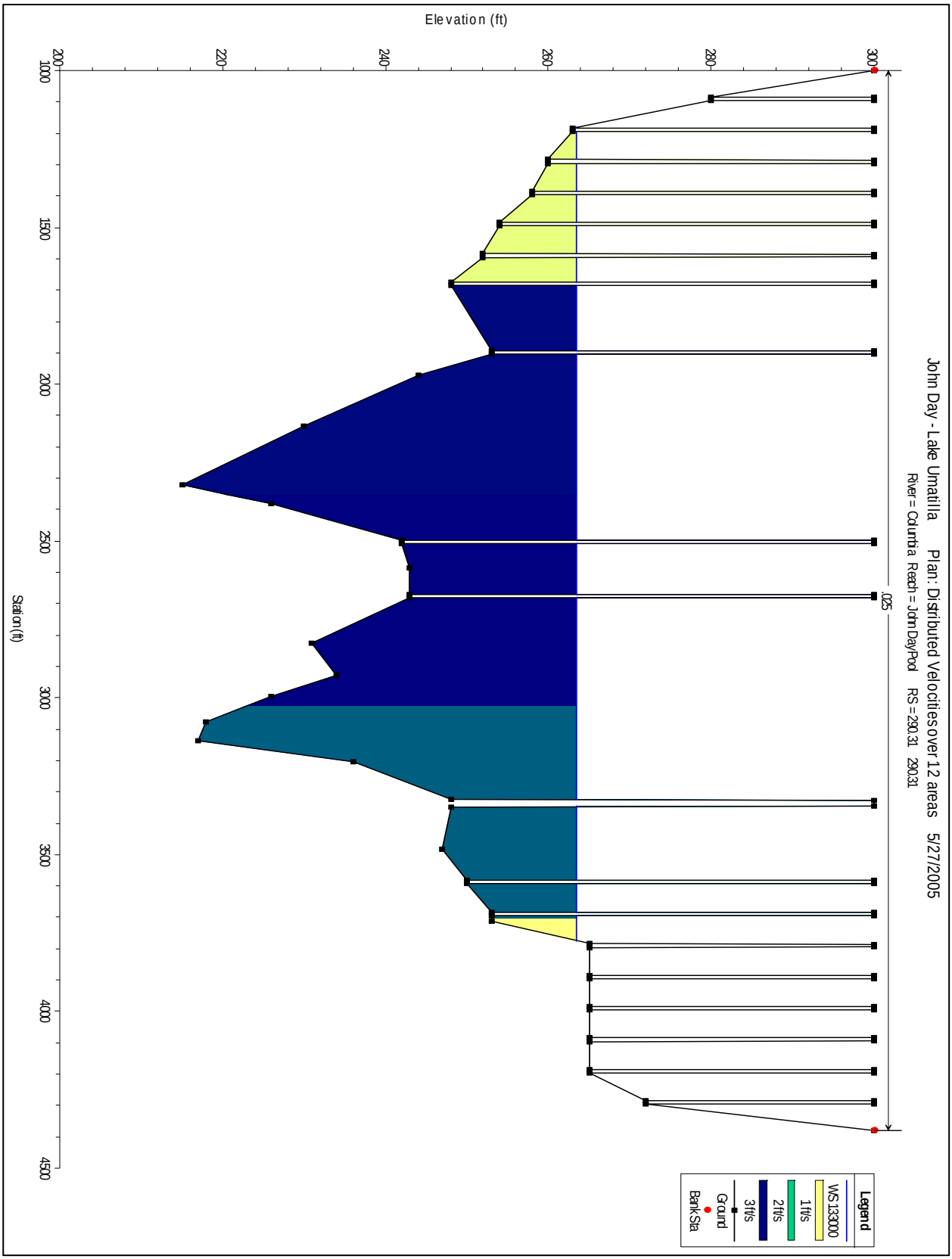
River = Columbia Reach = JohnDayPod RS = 291.41 29141
Elevation (ft)
Station (ft)
180
200
220
240
260
280
300
1000
2000
3000
4000
5000
6000
.04
.025
.99
Legend
WS 140000
0ft/s
1ft/s
2ft/s
3ft/s
Ground
Bank Sta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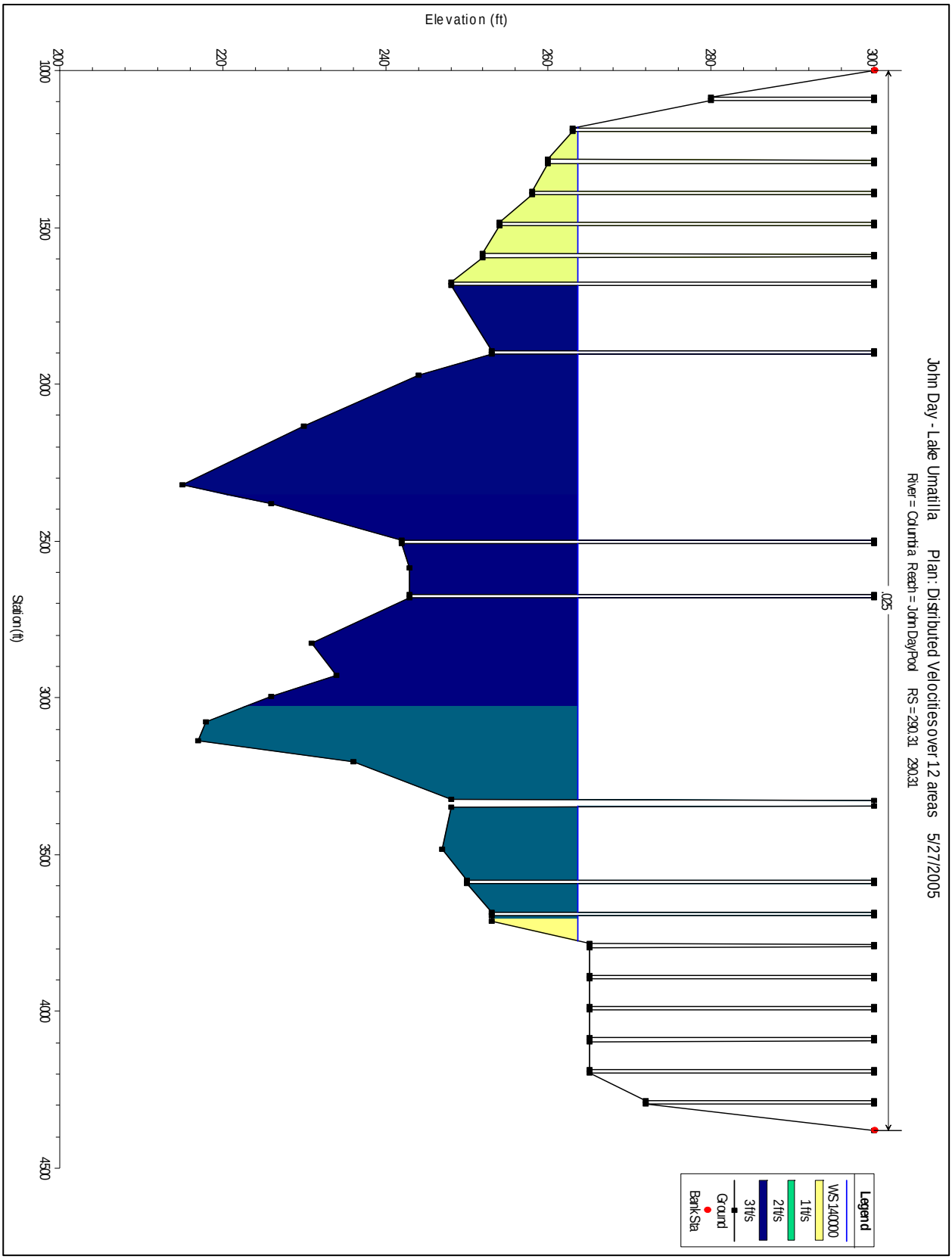
Elevation (ft)
Station (ft)
Legend
WS 133000
1ft/s
2ft/s
3ft/s
Ground
Bank Sta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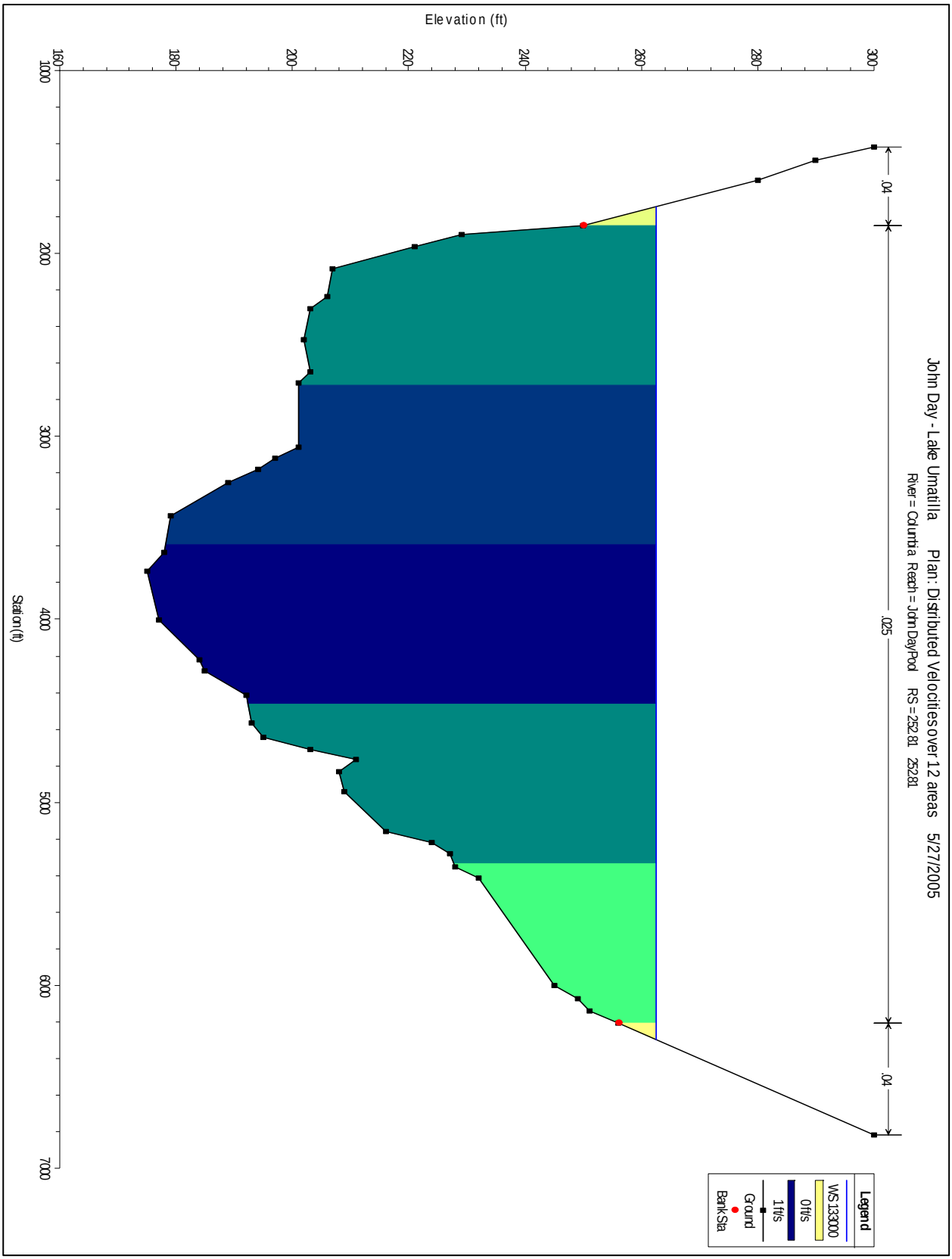
Elevation (ft)
Station (ft)
200
220
240
260
280
300
1000
1500
2000
2500
3000
3500
4000
4500
025
Legend
WS 140000
1 ft/s
2 ft/s
3 ft/s
Ground
Bank Sta


John Day - Lake Umatilla Plan: Distributed Velocities over 12 areas 5/27/2005
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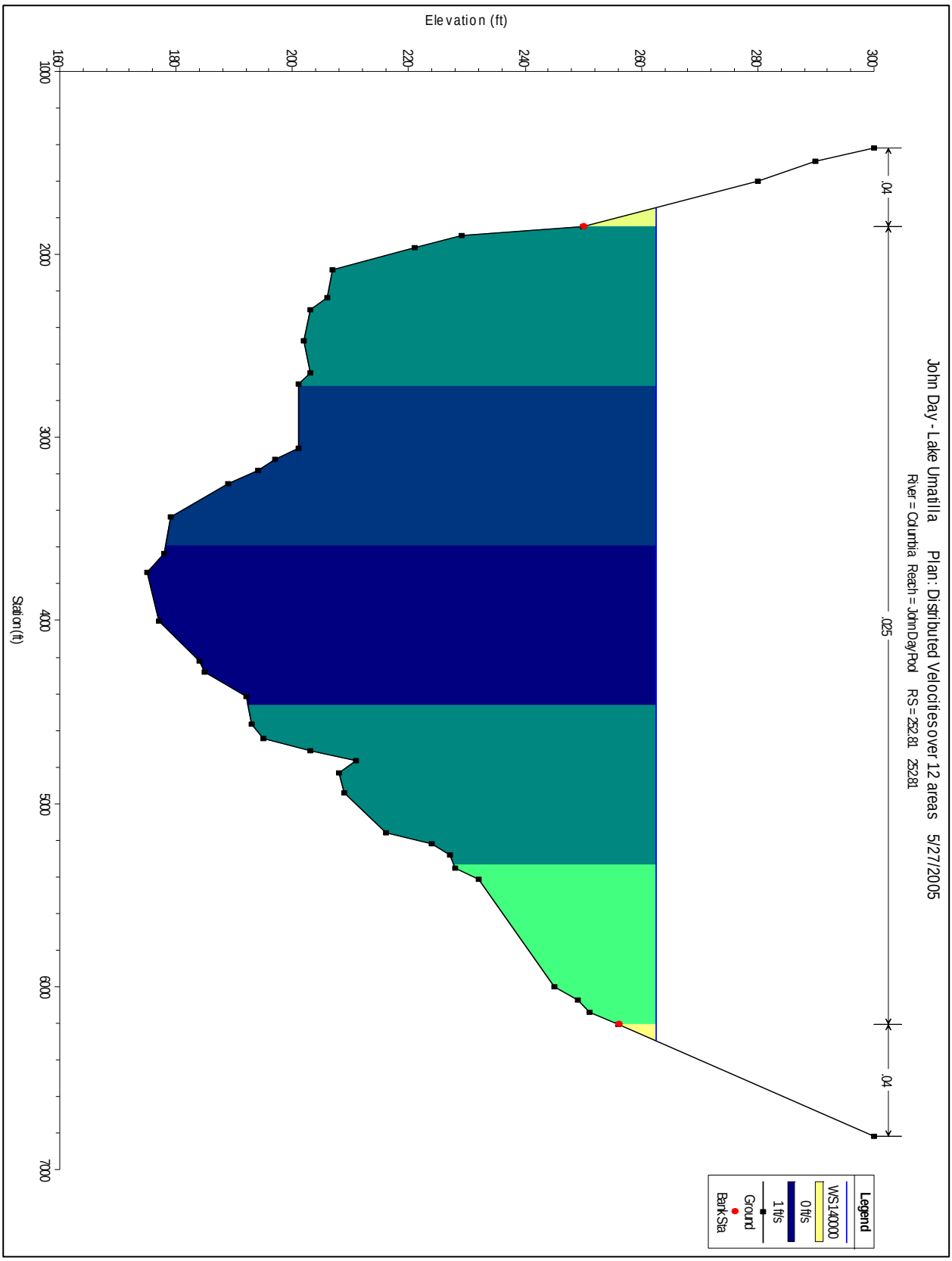
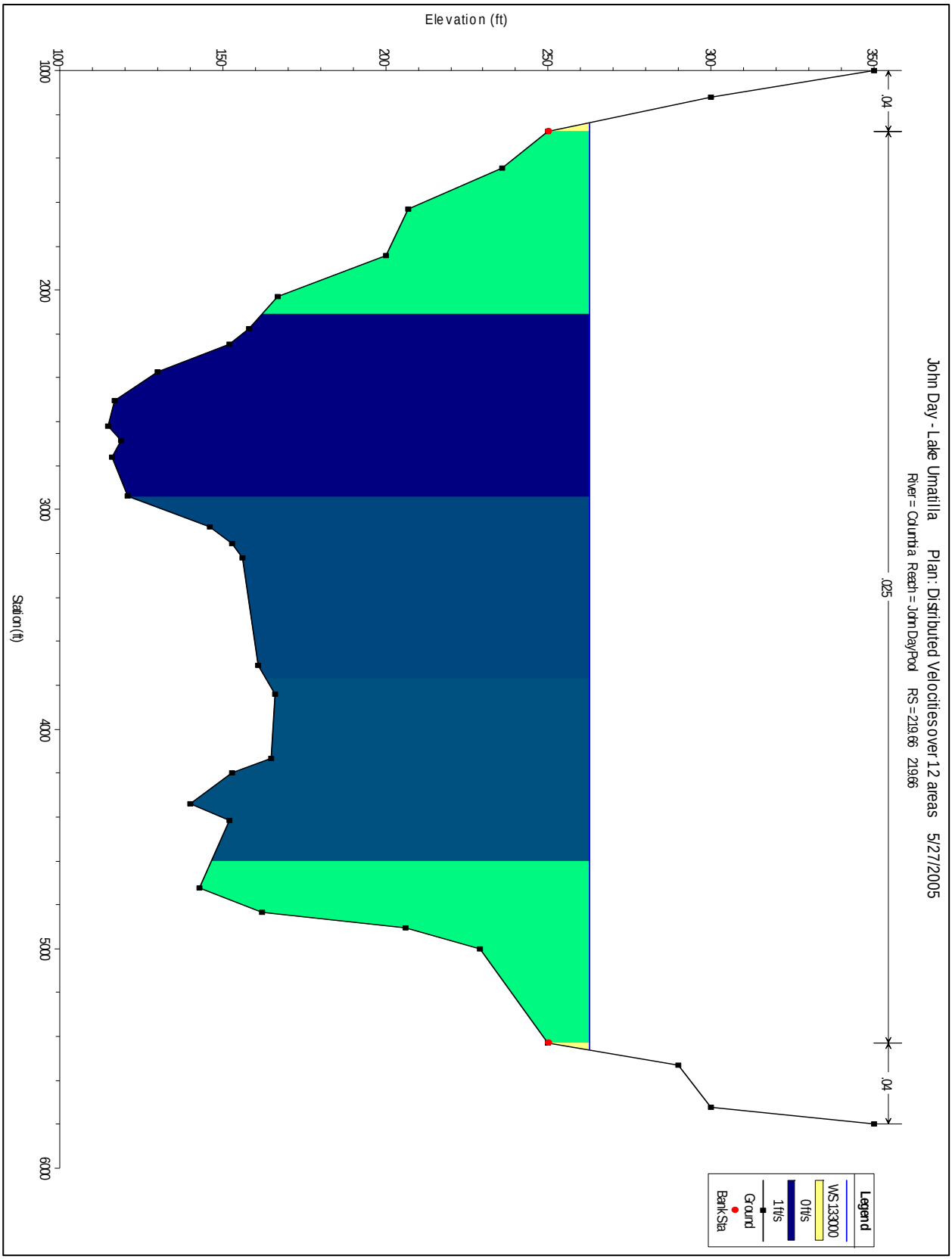
Elevation (ft)
Station (ft)
160
180
200
220
240
260
280
300
1000
2000
3000
4000
5000
6000
7000
.04
.025
.04
Legend
WS 133000
0 ft/s
1 ft/s
Ground
Bank Sta


John Day - Lake Umatilla Plan: Distributed Velocities over 12 areas 5/27/2005
River = Columbia Reach = JohnDayPool RS = 252.81 252.81
Elevation (ft)
Station (ft)
160
180
200
220
240
260
280
300
1000
2000
3000
4000
5000
6000
7000
.04
.025
.04
Legend
WS140000
0 ft/s
1 ft/s
Ground
Bank Sta


John Day - Lake Umatilla Plan: Distributed Velocities over 12 areas 5/27/2005
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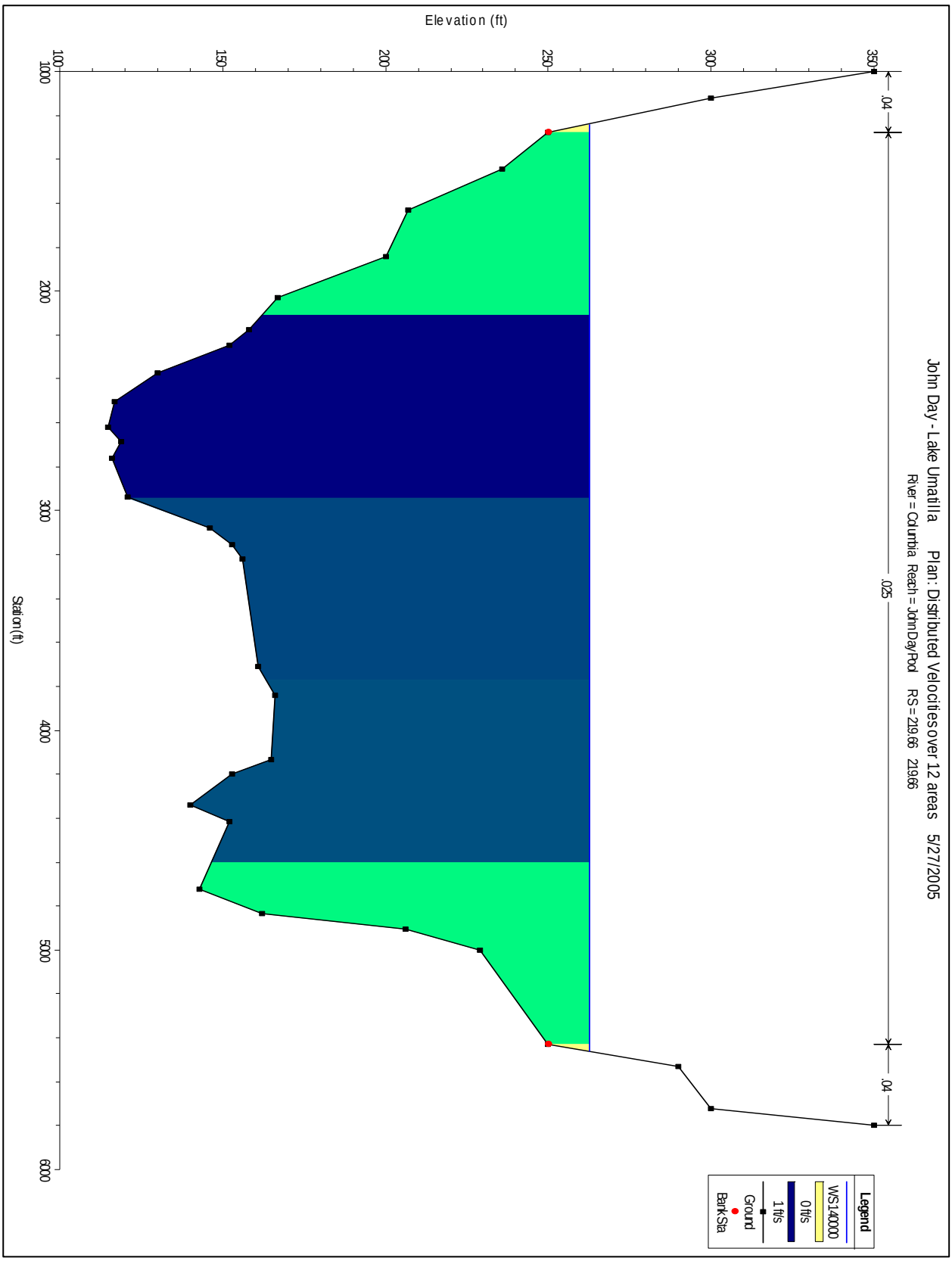
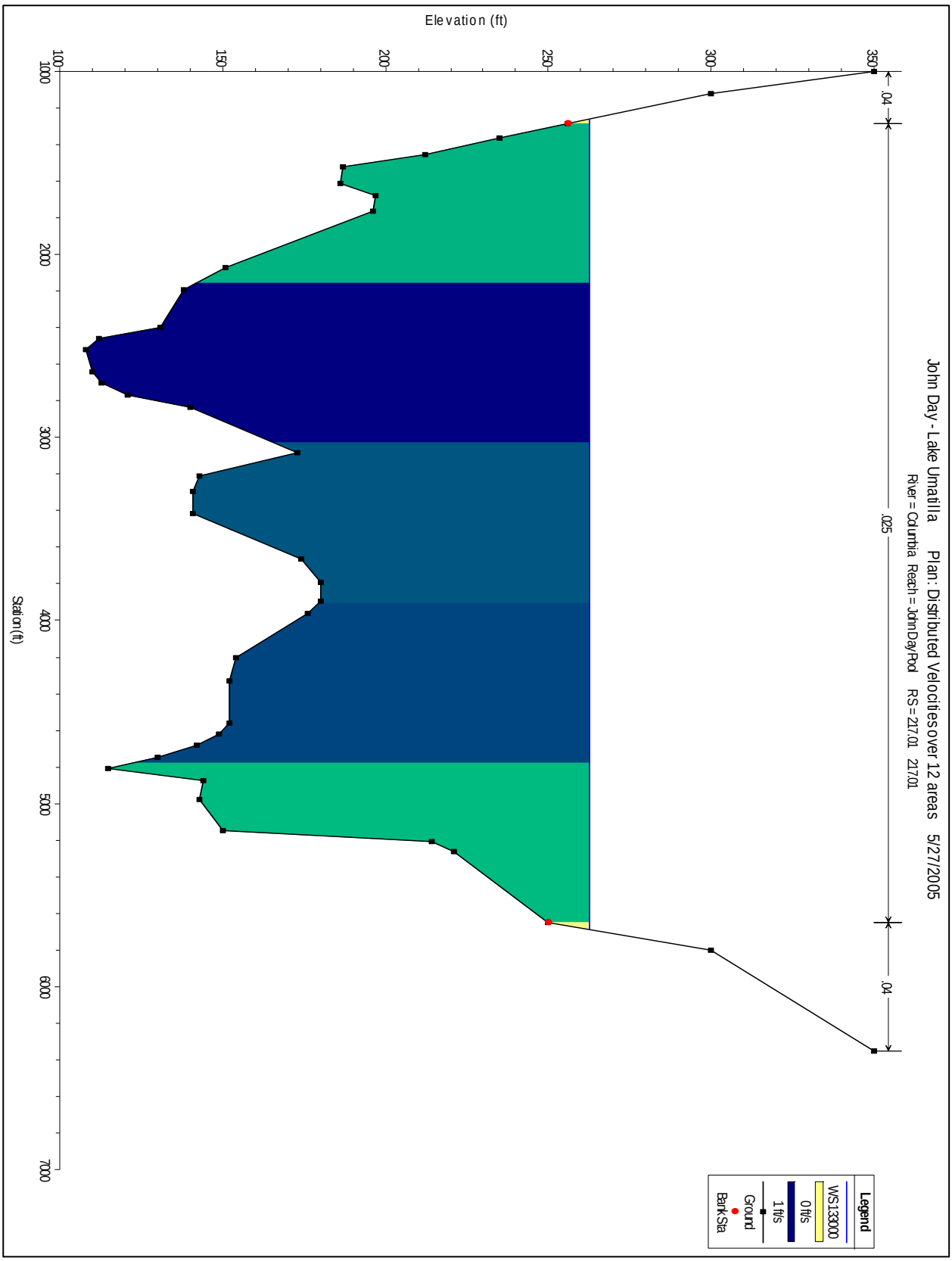
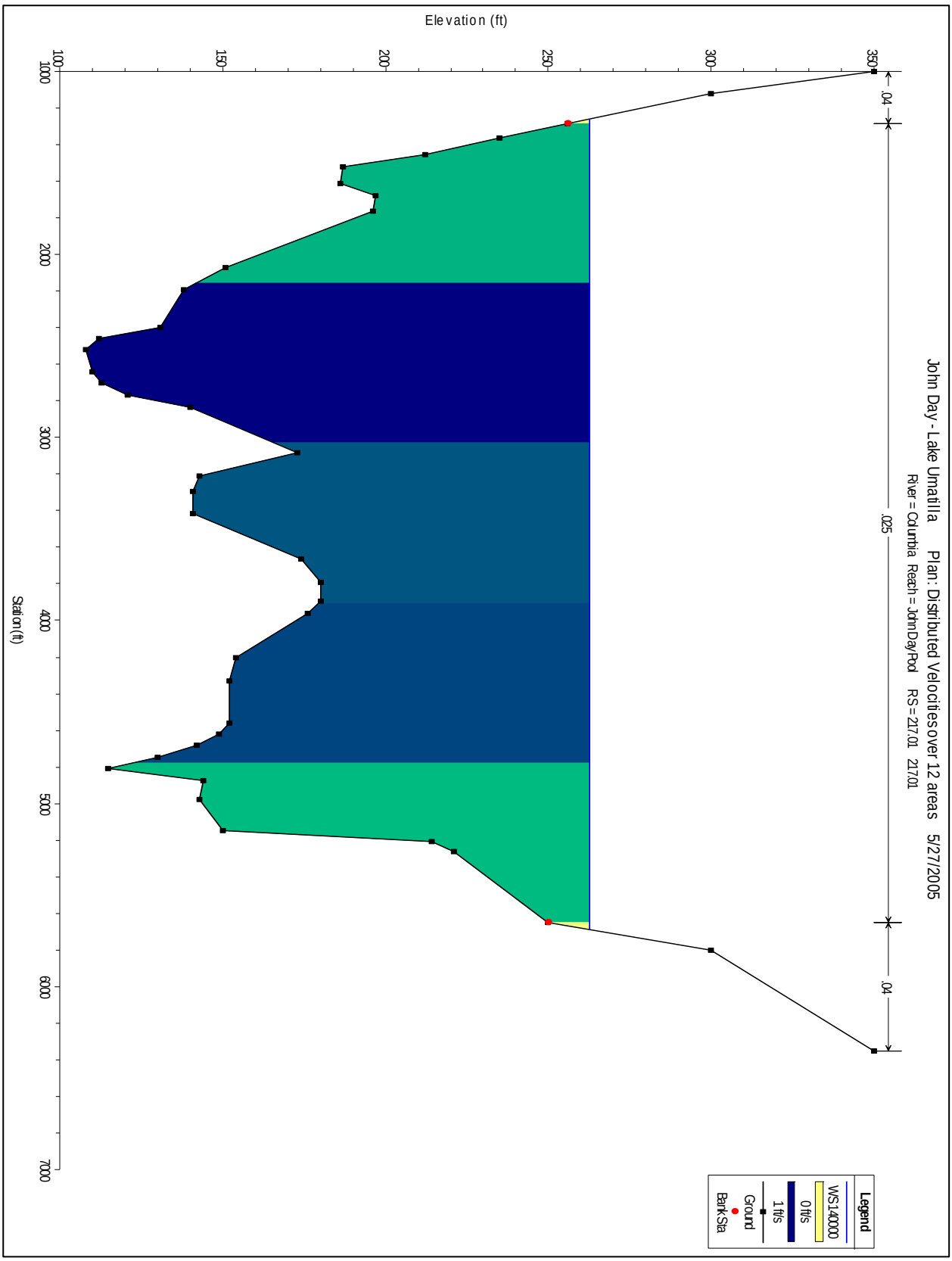
Elevation (ft)
Station (ft)
100
150
200
250
300
350
1000
2000
3000
4000
5000
6000
.04
.025
.04
Legend
WS 133000
0 ft/s
1 ft/s
Ground
Bank Sta


John Day - Lake Umatilla Plan: Distributed Velocities over 12 areas 5/27/2005
River = Columbia Reach = JohnDayPool RS = 219.66 219.66
Elevation (ft)
Station (ft)
100
150
200
250
300
350
1000
2000
3000
4000
5000
6000
.04
.025
.04
Legend
WS140000
0 ft/s
1 ft/s
Ground
Bank Sta


John Day - Lake Umatilla Plan: Distributed Velocities over 12 areas 5/27/2005
River = Columbia Reach = JohnDayPool RS = 217.01 217.01
Elevation (ft)
Station (ft)
100
150
200
250
300
350
1000
2000
3000
4000
5000
6000
7000
.04
.025
.04
Legend
WS133300
0 ft/s
1 ft/s
Ground
Bank Sta


John Day - Lake Umatilla Plan: Distributed Velocities over 12 areas 5/27/2005
River = Columbia Reach = JohnDayPool RS = 217.01 217.01
Elevation (ft)
Station (ft)
100
150
200
250
300
350
1000
2000
3000
4000
5000
6000
7000
.04
.025
.04
Legend
WS140000
0 ft/s
1 ft/s
Ground
Bank Sta